Chapter 4
Exposure Scenario Identification

What's Covered in Chapter 4:

- ♦ Exposure Setting Characterization
- ♦ Recommended Exposure Scenarios
  - Subsistence Farmer
  - Subsistence Farmer Child
  - Adult Resident
  - Child Resident
  - Subsistence Fisher
  - Subsistence Fisher Child
  - Acute Risk
- ♦ Exposure Scenario Locations

The purpose of this chapter is to provide guidance in the identification of "exposure scenarios" that should be evaluated in the risk assessment to estimate the type and magnitude of human exposure to COPC emissions from hazardous waste combustion units (including fugitive emissions). Identification of the exposure scenarios to be evaluated includes characterization of exposure setting, identification of recommended exposure scenarios, and selection of exposure scenario locations.

An exposure scenario is a combination of "exposure pathways" to which a single "receptor" may be subjected. Human receptors may come into contact with COPCs emitted to the atmosphere from hazardous waste combustion units via two primary exposure "routes," either directly—via inhalation; or indirectly—via subsequent ingestion of water, soil, vegetation, and animals that become contaminated by COPCs through the food chain.

Exposure to COPCs may occur via numerous exposure pathways, which represent combinations of receptors and exposure routes. Each exposure pathway consists of four fundamental components: (1) an exposure route; (2) a source and mechanism of COPC release (see Chapter 2); (3) a retention medium, or a transport mechanism and subsequent retention medium in cases involving media transfer of COPCs (see Chapter 3 for air transport of COPCs, and Chapter 5 for bioaccumulation of COPCs in the food chain); and (4) a point of potential human contact with the contaminated medium, which is referred to as the exposure point and consists of a specific receptor exposed at a specific point. Humans, plants, and animals in the assessment area may take up COPCs directly from the air or indirectly via the media receiving deposition (e.g., soil, vegetation, or water).

The exposure scenarios recommended for evaluation in this guidance are generally conservative in nature and not intended to be entirely representative of actual scenarios at all sites. Rather, they are intended to allow standardized and reproducible evaluation of risks across most sites and land use areas, with conservatism incorporated to ensure protectiveness of potential receptors not directly evaluated, such as special subpopulations and regionally specific land uses. U.S. EPA OSW believes that the recommended exposure scenarios and associated assumptions presented in this chapter are reasonable and conservative, and that they represent a scientifically sound approach that allows protection of human health and the environment while recognizing the uncertainty associated with evaluating real world exposure. Unless site-specific conditions warrant exception, as approved by the permitting authority, U.S. EPA OSW recommends that these scenarios be used, at a minimum, as an initial evaluation to indicate primary risk concerns. Any exceptions, such as a deletion or modification of a recommended exposure scenario, scenario location (see Section 4.3), or both, should be well-documented and approved by the permitting authority.

The following sections describe how to (1) characterize the exposure setting, (2) identify the U.S. EPA OSW-recommended exposure scenarios, and (3) select the exposure scenario locations to be evaluated in the risk assessment.

4.1 EXPOSURE SETTING CHARACTERIZATION

The purpose of characterizing the exposure setting is to identify the non-worker related human activities and receptors in the assessment area—both inside and outside of the facility property boundary—that may be impacted as a result of exposure to emissions from one or more of a facility's emission sources. Exposure setting characterization is generally focused on identifying current and reasonable potential human activities or land uses that provides the basis for evaluation of recommended exposure scenarios (see Section 4.2) that ensure protection of the general public, versus direct evaluation of worker related exposures. This is because there are other guidance and regulations for occupational exposures to hazardous waste and hazardous waste combustion emissions within the facility boundary, such as U.S. Occupational Safety and Health Administration (OSHA), which promulgates health standards based on exposures to workers for a 40-hour work week. However, there may be some instances (e.g., acute risk) where worker exposure at nearby facilities or commercial areas within the assessment area are considered within the risk assessment.

Exposure setting characterization is generally limited to the assessment area that is defined by a 50-km radius, taken from the centroid of a polygon (also used as the origin of ISCST3 receptor grid node array, see Chapter 3) identified by the UTM coordinates of the facility stacks. A 50-km radius is generally recognized limit of the ISCST3 air dispersion model and predecessors (U.S. EPA 1990e; 1994c). However, resources for characterizing the exposure setting should initially be focused on the areas surrounding the emission sources and extending out to about 3-km; where the most significant deposition has been observed in most cases. The assessment area should include facility and non-facility property since experience has shown that some facilities located on substantial property may rent portions of the property to the public for farming, ranching, or recreational purposes (e.g., fishing). Therefore, land use and water bodies—both inside and outside the facility property boundary—should be considered for evaluation.

The purpose of characterizing the exposure setting is to identify current and reasonable potential human activities or land uses that provides the basis for evaluation of recommended exposure scenarios (see Section 4.2), and that may be impacted as a result of exposure to emissions from one or more of a facility's emission sources. The following subsections provide information on (1) current and reasonable potential future land use, (2) waterbodies and their associated watersheds, and (3) special subpopulations. Characterization of the exposure setting specific to each site's land use and each facility's emissions is critical to ensuring that relevant and accurate estimates of exposure are considered in the risk assessment.

4.1.1 Current and Reasonable Potential Future Land Use

Current and reasonable potential future land use are important factors to consider in characterizing the exposure setting; and when overlayed with the air dispersion modeling results, will define which recommended exposure scenarios and their locations should be evaluated in the risk assessment. In addition to current land use, reasonable potential future land use is also important because risk assessments evaluate the potential risks from facilities over long periods of time (greater than 30 years). Therefore, it is important to identify exposure scenario locations that are not only based on the current use of land, but also exposure scenario locations that consider reasonable potential future uses.

Current land use, and indications of future land use, can typically be identified by reviewing hard copy and/or electronic versions of land use land classification (LULC) maps, topographic maps, and aerial photographs. Sources and general information associated with each of these data types or maps are presented below. Also, as noted in Chapter 3, the UTM coordinate system format (NAD27 or NAD83) for all mapping information should be verified to ensure consistency and prevent erroneous georeferencing of locations and areas.

> ***Land Use Land Cover (LULC) Maps* -** LULC maps can be downloaded directly from the USGS web site (http://mapping.usgs.gov/index.html), at a scale of 1:250,000, in a file type GIRAS format. LULC maps can also be downloaded from the EPA web site (ftp://ftp.epa.gov/pub), at a scale of 1:250,000, in an Arc/Info export format. Exact boundaries of polygon land use area coverages, in areas being considered for evaluation, should be verified using available topographic maps and aerial photographic coverages.
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> ***Topographic Maps* -** Topographic maps are readily available in both hard copy and electronic format directly from USGS or numerous other vendors. These maps are commonly at a scale of 1:24,000, and in a file type TIFF format with TIFF World File included for georeferencing.
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> ***Aerial Photographs* -** Hard copy aerial photographs can be purchased directly from USGS in a variety of scales and coverages. Electronic format aerial photographs or Digital Ortho Quarter Quads (DOQQs) can also be purchased directly from USGS, or from an increasing number of commercial sources. Properly georeferenced DOQQs covering a 3-km or more radius of the assessment area, overlays of the LULC map coverage and the ISCST3 modeled receptor grid node array, provide an excellent reference for identifying land use areas and justifying selection of exposure scenario locations.

While obviously these data types or maps do not represent the universe of information available on human activities or land use, they are readily available from a number of government sources (typically accessible via the Internet), usually can be obtained for free or at low cost, and when used together provide sufficient information to reliably identify and define, in a defensible manner, land use areas to be considered for evaluation in the risk assessment. However, while the use of these or other data can be very accurate, verifying identified land use areas by conducting a site visit is recommended, if feasible. Also, discussions with representatives of private and government organizations which routinely collect and evaluate land use data (agricultural extension agencies, U.S. Department of Agriculture, natural resource and park agencies, and local governments) can be helpful in updating current land use information or providing information regarding future land use. Information on reasonable potential future land use can also be obtained from local planning and zoning authorities, which may help determine what level of development is now allowed under current regulations and what development is expected in the future.

Any known or reasonable potential future use of the land should be defined. For instance, a reasonable potential land use for a rural area that is currently characterized by open fields and intermittent housing, could reasonably be a residential subdivision that is developed in the future. Conversely, areas characterized as a tidal swamp could reasonably indicate that these areas will not become farms.

Areas with differing current and reasonable potential future land use characteristics should be defined for consideration of ISCST3 modeled receptor grid nodes within the defined land use area as possible exposure scenario locations (see Section 4.3). Land use characterization should identify population centers in the area (e.g., communities, residential developments, and rural residences), farms and ranches, and other land use type that may support recommended exposure scenarios as discussed in Section 4.2. For example, if an assessment area includes a farm and a small residential community, both of these areas should be identified so that receptor grid nodes within these areas can be further considered as possible exposure scenario locations (see Sections 4.2 and 4.3). The risk assessor should focus on land use areas potentially impacted by COPC emissions from facility emission sources being evaluated in the risk assessment.

Information on site-specific physiographic features may also be considered to provide a frame of reference for comparing default variables and associated assumptions (e.g., plant types, soil characteristics, land use, etc.) applied in the fate and transport models. For the purposes of the risk assessment, the presence, type, and extent of physiographic features can readily be determined by using the following sources: (1) USGS topographic maps, (2) Soil Conservation Service reports, (3) county and local land use maps, and (4) information from state departments of natural resources or similar agencies.

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- Identification and/or mapping of current land uses in the area, a description of the use, the area of the land described by the use, and the source of the information. Risk assessors should focus initially on those land use areas impacted by emissions of COPCs.
- Identification and/or mapping of the reasonable potential future land use areas, a description of the use, the source or rationale on which the description is based. Risk assessors should focus initially on those land use areas impacted by emissions of COPCs.

4.1.2 Water Bodies and Their Associated Watersheds

Water bodies and their associated watersheds are important factors in evaluating some of the recommended exposure scenarios discussed in Section 4.2. For example, the identification of surface water bodies at locations in the assessment area receiving deposition from emission sources indicates the potential for COPC exposures from ingestion of fish, and possibly drinking water (drinking water is evaluated only if the local population obtains drinking water from surface water sources). In addition to identifying human uses associated with water bodies potentially impacted by COPC emissions, the surface area and exact location with respect to evaluating receptor grid nodes positioned within the water body should be defined. Likewise, the area and exact location with respect to evaluating receptor grid nodes positioned within the watershed should also be defined. Discussion on selection of exposure scenario locations associated with water bodies, and evaluating the ISCST3 air parameter concentrations at receptor grid nodes within the water body and associated watershed can be found in Section 4.3.

Use, area, and location of water bodies and their associated watersheds can typically be identified by reviewing the same hard copy and /or electronic versions of land use land classification (LULC) maps, topographic maps, and aerial photographs used in identification of land use. Sources and general information associated with each of these data types or maps are presented in Section 4.1.1.

Additional information on water body use can also be obtained through discussions with local authorities (e.g., state environmental agencies, fish and wildlife agencies, or local water control districts) about viability to support fish populations and drinking water sources, or current postings of fish advisories. However, risks will generally be estimated for a water body even if a fish advisory is posted. Surface water bodies that are used for drinking water sources in the assessment area should generally be evaluated in the risk assessment. While water bodies closest to the facility will generally have higher deposition rates, estimated risk is also determined by other physical parameters, including the area extent or size of the water body and the associated watershed, and by the properties of the COPCs being emitted.

For water bodies identified as potentially impacted from emission sources and selected for evaluation, the area extent of the associated watershed that contributes water to the water body should also be identified and defined by UTM coordinates. The area extent of a watershed is generally defined by topographic highs that result in downslope drainage into the water body. The watershed can be important to determining the overall water body COPC loading, because pervious and impervious areas of the watershed, as well as the soil concentration of COPCs resulting from emissions from facility sources, are also used in the media concentration equations to calculate the water body COPC concentrations resulting from watershed runoff (see Chapter 5 and Appendix B). The total watershed area that contributes water to the water body can be very extensive relative to the area that is impacted from facility emissions. Therefore, it is important that the area extent of all watersheds to be evaluated should be approved by the permitting authority, to ensure that the watershed and it's contribution to the water body is defined appropriately in consideration of the exposure scenario location (e.g., location on the water body of the drinking water intake, fishing pier, etc.) for the water body being evaluated and subsequent estimated risk.

For example, if facility emissions impact principally a land area that feeds a specific tributary that drains to a large river system and immediately upstream of a drinking water intake point, the risk assessor should consider evaluating an "effective" watershed area rather than the entire watershed area of the large river system. For such a large river system, the watershed area can be on the order of thousands of square kilometers and can include numerous tributaries draining into the river at points that would have no net impact on the drinking water intake or on the water body COPC concentration at the exposure point of interest.

As previously discussed, additional water body and watershed parameters (on an average annual basis) to be determined include the following:

- Water body surface area
- Watershed surface area
- Impervious watershed area
- Average surface water volumetric flow rate
- Current velocity of surface water body
- Depth of surface water body column
- Universal Soil Loss Equation (USLE) rainfall/erosivity factor

The impervious watershed area is generally a function of urbanization within the watershed, and is typically presented as a percentage of the total watershed area. Water body current velocities and volumetric flow rates should generally be average values on an annual basis. State or local geologic surveys may keep records on water bodies. Volumetric flow rates for smaller streams or lakes can be calculated as the product of the watershed area and one-half of the local average annual surface runoff. Current velocities can be calculated as the volumetric flow rate divided by the cross-sectional area (current velocities are not used in the equations for lakes). Depths of water bodies can sometimes be obtained from state or local sources. Discussions on determining the USLE rainfall/erosivity factor are included in Chapter 5 and Appendix B.

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- Identification and/or mapping of water bodies and associated watersheds potentially impacted by facility emissions of COPCs, including surface area of the water body and area extent of the contributing watershed defined by UTM coordinates
- Rational for selection or exclusion from evaluation, water bodies within the assessment area
- Documentation of water body area, watershed area, impervious area, volumetric flow rate, current velocity, depth of water column, and the USLE rainfall/erosivity factor
- Description of assumptions made to limit the watershed area to an "effective" area
- Copies of all maps, photographs, or figures used to define water body and watershed characteristics
- Information on water body use that may justify inclusion or exclusion of the water body from evaluation in the risk assessment

4.1.3 Special Subpopulation Characteristics

Special subpopulations are defined as human receptors or segments in the population that may be potentially at higher risk due to receptor sensitivity to COPCs (e.g., elderly, infants and children, fetus of pregnant women). The assumptions specified in this guidance to complete the risk assessment (such as the conservative nature of the recommended exposure scenarios, see Section 4.2, and the use of RfDs which have been developed to account for toxicity to sensitive receptors) have been developed to protect human health—including special subpopulations. However, in addition to evaluation of the recommended exposure scenarios (see Section 4.2), the risk assessment may need to directly address special subpopulations in impacted areas because of characteristics of the exposure setting or to address specific community concerns; including new U.S. EPA policy focused on consistently and explicitly evaluating environmental health risks to infants and children in all risk assessments (U.S. EPA 1995j). For example, a day care center or hospital that is located in an area potentially impacted by facility emissions. Based on site-specific exposure characteristics, exposures to children at the day care center or to the sick in the hospital may need to be addressed because these receptors may be especially sensitive to the adverse effects of the COPCs emitted, and because the specific exposure setting is particularly conducive to exposure. Therefore, special subpopulations in such areas should be identified. Section 4.2 provides additional discussion on how potential exposure of special subpopulations can be evaluated consistent with evaluation of recommended exposure scenarios.

Because concerns about special subpopulations can arise at any time in the permitting process, the U.S. EPA OSW recommends that special subpopulations potentially at higher risk be identified in the exposure setting characterization for the risk assessment. Characterization should identify special subpopulations in the assessment area based on the location of schools, hospitals, nursing homes, day care centers, parks, community activity centers, etc. If available information indicates that there are children exhibiting pica behavior (defined for risk assessment purposes as "an abnormally high soil ingestion rate") in the assessment area, these children may represent a special subpopulation (see Section 6.2.3.1).

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- Identification and/or mapping of the locations of special subpopulations at potentially higher risk from exposure to facility sources (anticipated to be located in areas impacted by facility emissions); focusing on the characteristics of the exposure setting to ensure that selected exposure scenario locations are protective of the special populations.

4.2 RECOMMENDED EXPOSURE SCENARIOS

U.S. EPA OSW recommends the following exposure scenarios (also see Table 4-1):

- Subsistence Farmer
- Subsistence Farmer Child
- Adult Resident
- Child Resident
- Subsistence Fisher
- Subsistence Fisher Child

- Acute Risk

These are the same exposure scenarios recommended by U.S. EPA (1994g) with the exception of the child farmer, child fisher, and acute risk. Evaluation of the subsistence farmer child scenario was introduced into the indirect screening process in the risk assessment completed to support the proposed Hazardous Waste Combustion Rule and by NC DEHNR (1997). The subsistence fisher child and acute risk scenarios advocated by this HHRAP are included for two primary reasons: (1) to be consistent with the adult/child pairings recommended for the resident and subsistence farmer scenarios, and (2) to ensure that the risk assessment evaluates all receptors that may be significantly exposed to emissions from facility sources.

In addition to the recommended exposure scenarios presented above, U.S. EPA OSW recommends evaluation of special subpopulations (as defined in Section 4.1.3) and communities of concern by identifying their locations, and determining whether they are located in areas with exposure setting characteristics that are particularly conducive to COPC impacts from facility emissions. Evaluation of special subpopulations or community concerns should be initially conducted by applying the recommended exposure scenario(s) (e.g., adult resident, child resident, acute risk) that are most representative of the exposure setting for the subpopulation to be evaluated; utilizing the maximum modeled air parameter values specific to the location (see Section 4.3). If initial evaluation, using the appropriate conservative recommended exposure scenarios, indicates potential risks at regulatory levels of concern, or if the subpopulation is not adequately represented by some of the exposure pathways in the initial evaluation, a refined evaluation more representative of the site-specific exposure setting characterization may be required by evaluating the specific exposure pathways applicable to the exposure occurring at the location.

For example, for a children's school or day care center located in an area impacted by facility sources, potential exposure to children at this location can be evaluated by completing the child resident scenario at the location of the school or day care. In most cases, evaluation of the child resident scenario at the school will be overly conservative because the ingestion of homegrown produce exposure pathway is most likely not occurring at that location. If necessary, a more refined evaluation that does not include ingestion of homegrown produce (only if supported by site-specific exposure setting characterization) can be conducted to provide a more accurate quantitative estimate of potential risk.

Although some of the recommended exposure scenarios are referred to as "subsistence", the actual mass per day amounts of food items (see homegrown ingestion rates, Appendix C) evaluated in the recommended exposure pathways (see Table 4-1) are more comparable to reasonable versus subsistence amounts; and therefore, may not preclude ingestion of significant amounts of food items not represented in the exposure pathways of the exposure scenario subject to evaluation. As indicated in Table 4-1, specific regional exposure setting characteristics may warrant that the permitting authority consider inclusion of additional recommended exposure pathways when evaluating an exposure scenario for a specific regional exposure setting. For example, the recommended subsistence farmer exposure scenario does not automatically include the fish ingestion exposure pathway. However, in some areas of the country, it is common for farms to also have stock ponds which are fished on a regular basis for the farmer's consumption. Since the recommended homegrown ingestion rates for produce and animal products (already considered in the evaluation) are not significant enough to reasonably prevent the farmer from also ingesting the fish caught from the local pond, the permitting authority may consider inclusion of the fish ingestion exposure pathway when evaluating a subsistence farmer exposure scenario at such locations that would reasonably indicate such an exposure setting (e.g., farms with stock ponds or near productive water bodies). This same type of example could also be considered for residential scenarios where residents are located in semi-rural areas which allow small livestock (e.g., free range poultry for eggs), and/or residents located by small ponds supporting fishing or wetlands supporting crawfish harvest.

U.S. EPA OSW also recommends that infant exposure to PCDDs and PCDFs via the ingestion of their mother's breast milk be evaluated as an additional exposure pathway at all recommended exposure scenario locations. Chapter 2 and Appendix C also further describe the ingestion of breast milk exposure pathway.

Also, although some risk assessments conducted by U.S. EPA (1996b) have discounted the direct inhalation risks to all receptors except the adult resident (nonfarmer) and child resident (nonfarmer), U.S. EPA OSW recommends that the direct inhalation exposure pathways be evaluated for all receptors.

U.S. EPA OSW does not typically recommend that the following exposure pathways be evaluated as part of any exposure scenario:

***Ingestion of Ground Water* -** U.S. EPA (1990e) found that ground water is an insignificant exposure pathway for combustion emissions; in addition, U.S. EPA (1994k) noted that uptake from ground water into food crops and livestock is minimal because of the hydrophobic nature of dioxin-like compounds. Evaluation of potential exposure to COPCs through ingestion of drinking water from surface water bodies is anticipated to be much more significant. Ingestion of ground water is further discussed in Section 6.2.4.2.

***Inhalation of Resuspended Dust* -** U.S. EPA (1990e) found that inhalation of resuspended dust was insignificant. Evaluation of exposure through direct inhalation of vapor and particle phase COPCs and incidental ingestion of soil are anticipated to be much more significant. Inhalation of resuspended dust is further discussed in Section 6.2.3.3.

Dermal Exposure to Surface Water, Soil, or Air - Available data indicate that the contribution of dermal exposure to soils to overall risk is typically small (U.S. EPA 1996g; 1995h). For example, the risk assessment conducted for the Waste Technologies Industries, Inc., hazardous waste incinerator in East Liverpool, Ohio, indicated that—for an adult subsistence farmer in a subarea with high exposures—the risk resulting from soil ingestion and dermal contact was 50-fold less than the risk from any other exposure pathway and 300-fold less than the total estimated risk (U.S. EPA 1996g; 1995h). In addition, the estimation of potential COPC exposure via the dermal exposure pathway is associated with significant uncertainties. The most significant of these uncertainties are associated with determining the impact of soil characteristics and the extent of exposure (e.g., the amount of soil on the skin and the length of exposure) on the estimation of compound-specific absorption fractions (ABS). Therefore, U.S. EPA OSW recommends not evaluating the dermal exposure to soil pathway as part of the recommended exposure scenarios. However, if either a facility of a permitting authority feel that site-specific conditions indicate dermal exposure to soil may contribute significantly to total soil-related exposures, U.S. EPA OSW recommends following the methodologies described in U.S. EPA NCEA document, *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (In Press). Dermal exposure is further discussed in Section 6.2.3.2 of this guidance.

Inhalation of COPCs and Ingestion of Water by Animals - These exposure pathways have not been included in the recommended exposure scenarios because the contribution of these pathways to total risk is anticipated to be negligible in comparison with that of the exposure pathways being evaluated. However, these exposure pathways may need to be evaluated on a case-by-case basis considering site-specific exposure setting characteristics.

U.S. EPA OSW-recommended exposure scenarios are further discussed in the following subsections. Table 4-1 presents the exposure pathways that should be evaluated for each of the recommended exposure scenarios.

4.2.1 Subsistence Farmer

The subsistence farmer exposure scenario is evaluated to account for the combination of exposure pathways to which a receptor may be exposed in a farm or ranch exposure setting. U.S. EPA OSW recommends including this scenario, because indirect ingestion routes may represent significant potential exposure to COPCs released from combustion sources (U.S. EPA 1990e; 1994l; 1994g; NC DEHNR 1997); the significance of these exposures is primarily related to the potential for COPCs to bioaccumulate up the food chain. The evaluation of these exposure scenarios are consistent with U.S. EPA (1994g) and NC DEHNR (1997). As indicated in Table 4-1, the subsistence farmer is assumed to be exposed to COPCs emitted from the facility through the following exposure pathways:

- Direct inhalation of vapors and particles
- Incidental ingestion of soil
- Ingestion of drinking water from surface water sources
- Ingestion of homegrown produce

TABLE 4-1

RECOMMENDED EXPOSURE SCENARIOS FOR EVALUATION IN A HUMAN HEALTH RISK ASSESSMENT

Exposure Pathways	Recommended Exposure Scenarios[a]						
	Subsistence Farmer	Subsistence Farmer Child	Adult Resident	Child Resident	Subsistence Fisher	Subsistence Fisher Child	Acute Risk[b]
Inhalation of Vapors and Particulates	•	•	•	•	•	•	•
Incidental Ingestion of Soil	•	•	•	•	•	•	--
Ingestion of Drinking Water from Surface Water Sources	•	•	•	•	•	•	--
Ingestion of Homegrown Produce	•	•	•	•	•	•	--
Ingestion of Homegrown Beef	•	•	--	--	--	--	--
Ingestion of Milk from Homegrown Cows	•	•	--	--	--	--	--
Ingestion of Homegrown Chicken	•	•	--	--	--	--	--
Ingestion of Eggs from Homegrown Chickens	•	•	d	d	d	d	--
Ingestion of Homegrown Pork	•	•	--	--	--	--	--
Ingestion of Fish	d	d	d	d	•	•	--
Ingestion of Breast Milk	c	c	c	c	c	c	--

Notes:

[a] Exposure scenarios are defined as a combination of exposure pathways evaluated for a receptor at a specific exposure scenario location (receptor grid node).

[b] The acute risk scenario evaluates short-term 1-hour maximum COPC air concentrations (see Chapter 3) at any land use area that would support the other recommended exposure scenarios, as well as, commercial and industrial land use areas (excluding workers at the facility being directly evaluated in the risk assessment).

[c] Infant exposure to PCDDs and PCDFs via the ingestion of their mother's breast milk is evaluated as an additional exposure pathway, separately from the recommended exposure scenarios identified in this table (see Chapter 2).

[d] Regional specific exposure setting characteristics (e.g., presence of ponds on farms or within semi-rural residential areas, presence of lite livestock within semi-rural residential areas) may warrant that the permitting authority consider inclusion of this exposure pathway when evaluating a recommended exposure scenario (see Section 4.2).

- Ingestion of homegrown beef
- Ingestion of milk from homegrown cows
- Ingestion of homegrown chicken
- Ingestion of eggs from homegrown chickens
- Ingestion of homegrown pork
- Ingestion of breast milk (evaluated separately; see Chapter 2)

Previous U.S. EPA guidance documents (for example, U.S. EPA 1993h and U.S. EPA 1994f) have not included evaluating the concentration of COPCs in chicken and eggs. NC DEHNR (1997) considers chicken and egg ingestion pathways only for exposures to dioxins and furans, because *BCF* values were available in the literature only for dioxins and furans. Currently, biotransfer factors can be derived from literature data for other organic compounds and metals. Therefore, U.S. EPA OSW recommends the evaluation of the concentrations of all COPCs via chicken and egg ingestion exposure pathways. Further discussion of these exposure pathways, including numeric equations, parameters values, and COPC specific inputs, can be found in Chapter 5 and Appendices A, B, and C.

For the subsistence farmer scenario, the receptor is assumed to consume a fraction from each food group (beef, pork, poultry, eggs, and milk) to make up a total consumption rate, and all amounts consumed are assumed to be homegrown. This allows estimation of the relative contribution of COPC-specific risk from ingestion of each food group. If site-specific information is available that demonstrates that a subsistence farmer does not raise beef, poultry, or pork, and that raising any of these livestock would not occur for a reasonable potential future subsistence farmer at a location, then elimination of one or more of these exposure pathways from the risk evaluation could justifiably be considered. However, intakes rates of the food items consumed in the remaining exposure pathways may need to be adjusted upward to ensure that the total amount consumed (summed fraction from each food group) is representative of a subsistence level.

It should be noted that the ingestion rates of beef, poultry, eggs, and pork recommended (see Chapter 6 and Appendix C) for the subsistence farmer scenario represent a fraction of the total amount of meat and eggs consumed. Therefore, the approach of conducting the initial evaluation assuming ingestion of all meat groups by the subsistence farmer scenario does not grossly overestimate the total amount of meat a farmer or rancher could reasonably consume.

When evaluating the ingestion of drinking water from surface water for the subsistence farmer scenario, the potential for ingestion of cistern water at farm or ranch locations should also be considered in addition to surface water sources. If it can be determined based on available information, including site-specific information, interviews with local health departments, or other local information sources, that cistern water is likely to or could be used for a drinking water source, ingestion of cistern water should be evaluated similar to ingestion of water from a surface water body. Quantitative evaluation can be completed using the applicable estimating media concentration equations for ingestion of drinking water as presented in Chapter 5 and Appendix B.

The ingestion of fish exposure pathway is not recommended for automatic inclusion when evaluating the subsistence farmer exposure scenario. However, as indicated in the notes to Table 4-1, U.S. EPA OSW does recommend that the fish ingestion pathway be considered for evaluation if regional or site-specific exposure setting characteristics (e.g., presence of ponds on farms or ranches that support fish for human consumption) are identified that warrant consideration. Quantitative evaluation can be completed using the applicable estimating media concentration equations for ingestion of fish as presented in Chapter 5 and Appendix B. Also, the permitting authority may elect to evaluate the subsistence fisher and subsistence fisher child exposure scenarios (see Sections 4.2.5 and 4.2.6) at farm or ranch locations where on-site farm ponds are used as a potential source of fish for the purpose of human consumption.

Exposure of an infant to PCDDs and PCDFs via the ingestion of breast milk is evaluated as an additional exposure pathway, separately from this exposure scenario (see Chapter 2).

4.2.2 Subsistence Farmer Child

The subsistence farmer child exposure scenario is evaluated to account for the combination of exposure pathways to which a receptor may be exposed in a farm or ranch setting. U.S. EPA OSW recommends including the subsistence farmer child scenario, because indirect ingestion routes may represent significant potential exposure to COPCs released from combustion sources (U.S. EPA 1990e; 1994l; 1994g; NC DEHNR 1997); the significance of these exposures is primarily related to the potential for

COPCs to bioaccumulate up the food chain. The evaluation of this exposure scenario is consistent with U.S. EPA (1994g) and NC DEHNR (1997), and new U.S. EPA policy focused on consistently and explicitly evaluating environmental health risks to infants and children in all risk assessments (U.S. EPA 1995j). As indicated in Table 4-1 and Section 4.2.1, the subsistence farmer child is assumed to be exposed to COPCs emitted from the facility through the same exposure pathways as the subsistence farmer.

4.2.3 Adult Resident

The adult resident exposure scenario is evaluated to account for the combination of exposure pathways to which a receptor may be exposed in an urban or rural (nonfarm) setting. U.S. EPA OSW recommends including the adult resident scenario, because potential exposure to COPCs through ingestion of homegrown produce has been shown to be potentially significant; the significance of these exposures is primarily related to the potential for COPCs to bioaccumulate up the food chain (U.S. EPA 1990e; 1994l; 1994g; NC DEHNR 1997). The evaluation of this exposure scenario is consistent with the evaluation of the "Home Gardener" scenario recommended by U.S. EPA (1994g) and NC DEHNR (1997). As indicated in Table 4-1, the adult resident is assumed to be exposed to COPCs from the emission source through the following exposure pathways:

- Direct inhalation of vapors and particles
- Incidental ingestion of soil
- Ingestion of drinking water from surface water sources
- Ingestion of homegrown produce
- Ingestion of breast milk (evaluated separately; see Chapter 2)

Further discussion of these exposure pathways, including numeric equations, parameters values, and COPC specific inputs, can be found in Chapter 5 and Appendices A, B, and C. Adult residents are assumed to grow some of their own produce (NC DEHNR 1997).

The ingestion of fish exposure pathway is not recommended for automatic inclusion when evaluating the resident adult exposure scenario. However, as indicated in the notes to Table 4-1, U.S. EPA OSW does recommend that the fish ingestion pathway be considered for evaluation if regional or site-specific exposure setting characteristics (e.g., presence of ponds within semi-rural residential areas that support fish for human consumption) are identified that warrant consideration. The permitting authority may elect to evaluate the subsistence fisher and subsistence fisher child exposure scenarios (see Sections 4.2.5 and 4.2.6) at residential locations where ponds or surface water bodies are used as a potential source of fish for the purpose of human consumption.

Exposure of an infant to PCDDs and PCDFs via the ingestion of breast milk is evaluated as an additional exposure pathway, separately from this exposure scenario (see Chapter 2).

4.2.4 Child Resident

The child resident exposure scenario is evaluated to account for the combination of exposure pathways to which a child receptor may be exposed in an urban or rural (nonfarm) setting. U.S. EPA OSW recommends including the adult resident child scenario, because indirect ingestion routes may represent significant potential exposure to COPCs released from combustion sources (U.S. EPA 1990e; 1994l; 1994g; NC DEHNR 1997); the significance of these exposures is primarily related to the potential for COPCs to bioaccumulate up the food chain. The evaluation of this exposure scenario is consistent with the evaluation of the “Child of the Home Gardener” scenario recommended by U.S. EPA (1994g) and NC DEHNR (1997), and new U.S. EPA policy focused on consistently and explicitly evaluating environmental health risks to infants and children in all risk assessments (U.S. EPA 1995j). As indicated in Table 4-1 and Section 4.2.3, the child resident is assumed to be exposed to COPCs emitted from the facility through the same exposure pathways as the resident adult. The child resident is assumed to ingest some produce grown by the adult resident (NC DEHNR 1997).

4.2.5 Subsistence Fisher

The Subsistence Fisher exposure scenario is evaluated to account for the combination of exposure pathways to which a receptor may be exposed in an urban or rural setting where fish is the main component of the receptor diet. U.S. EPA OSW recommends including the subsistence fisher scenario, because indirect ingestion routes may represent significant potential exposure to COPCs released from combustion sources (U.S. EPA 1990e; 1994l; 1994g; NC DEHNR 1997); the significance of these exposures is primarily related to the potential for COPCs to bioaccumulate up the food chain. The evaluation of this exposure scenario is consistent with U.S. EPA (1994g) and NC DEHNR (1997). As indicated in Table 4-1, the subsistence fisher is assumed to be exposed to COPCs emitted from the facility through the following exposure pathways:

- Direct inhalation of vapors and particles
- Incidental ingestion of soil
- Ingestion of drinking water from surface water sources
- Ingestion of homegrown produce
- Ingestion of fish
- Ingestion of breast milk (evaluated separately; see Chapter 2)

Further discussion of these exposure pathways, including numeric equations, parameters values, and COPC specific inputs, can be found in Chapter 5 and Appendices A, B, and C. Subsistence fishers are assumed to grow some of their own produce (NC DEHNR 1997). There may be many subsistence fishers throughout parts of several U.S. EPA regions. In fact, areas that are suspected to include large numbers of subsistence fishers, such as southeast Texas and southern Louisiana, are also areas with numerous hazardous waste combustion units.

Exposure of an infant to PCDDs and PCDFs via the ingestion of breast milk is evaluated as an additional exposure pathway, separately from this exposure scenario (see Chapter 2).

4.2.6 Subsistence Fisher Child

The subsistence fisher child exposure scenario is evaluated to account for the combination of exposure pathways to which a receptor may be exposed in an urban or rural setting where fish is the main component of the receptor diet. U.S. EPA (1994g) and NC DEHNR (1997) do not specifically recommend evaluation of this exposure scenario. However, the evaluation of this exposure scenario is consistent with the adult/child pairings recommended by U.S. EPA (1994g) and NC DEHNR (1997) for the subsistence farmer and residents, and new U.S. EPA policy focused on consistently and explicitly evaluating environmental health risks to infants and children in all risk assessments (U.S. EPA 1995j). As indicated in Table 4-1 and Section 4.2.5, the subsistence fisher child is assumed to be exposed to COPCs emitted from the facility through the same exposure pathways as the subsistence fisher. The subsistence fisher child is assumed to ingest some produce grown by the subsistence fisher; this assumption is similar to that for adult and child residents (NC DEHNR 1997).

4.2.7 Acute Risk Scenario

In addition to long-term chronic effects evaluated in the other recommended exposure scenarios, the acute exposure scenario is evaluated to account for short-term effects of exposure to maximum 1-hour concentrations of COPCs in emissions (see Chapter 3) from the facility through direct inhalation of vapors and particles (see Table 4-1 and Chapter 7). A receptor may be exposed in an urban or rural setting where human activity or land use supports any of the recommended exposure scenarios, as well as, in commercial and industrial land use areas (excluding workers from the facility under direct evaluation in the risk assessment) not typically evaluated by application of the other recommended exposure scenarios. Workers from the facility under direct evaluation in the risk assessment are excluded in most cases, because there are other guidance and regulations for occupational exposures to hazardous waste and hazardous waste combustion emissions within the facility boundary (e.g., OSHA).

Further discussion evaluation of this recommended exposure scenario and associated exposure pathway, including numeric equations, parameters values, and COPC specific inputs, can be found in Chapter 7 and Appendices A, B, and C.

4.3 SELECTION OF EXPOSURE SCENARIO LOCATIONS

Exposure scenario locations are the receptor grid nodes (defined by UTM coordinates during air dispersion modeling, see Chapter 3) selected as the location for evaluating one or more of the recommended exposure scenarios. Specific receptor grid nodes are selected as exposure scenario locations based on evaluation of the magnitude of air parameter values estimated by ISCST3 (see Chapter 3) specific to current and reasonable potential future land use areas as defined during the exposure setting characterization (see Section 4.1). Air parameter values specific to the receptor grid node, selected as an exposure scenario location, are then used as inputs to the estimating media concentration equations when evaluating the recommended exposure scenario(s) for that location. U.S. EPA OSW would like to note that the methodology and resulting selection of receptor grid nodes as exposure scenario locations is one of the most critical parts of the risk assessment process, ensuring standardization across all facilities evaluated and reproducibility of results. The estimates of risk can vary significantly in direct response to which receptor grid nodes are selected as exposure scenario locations; and therefore, which ISCST3 modeled air parameter values are used as inputs into the estimating media equations.

To ensure consistent and reproducible risk assessments, U.S. EPA OSW recommends that, at a minimum, the following procedures be used in the selection of receptor grid nodes as exposure scenario locations, and that selected exposure scenario locations correspond to actual ISCST3 modeled receptor grid node locations defined by UTM coordinates. In addition to consistency and reproducibility, these procedures ensure that the exposure scenario location(s) selected for evaluation over a specified land use area do not overlook locations within that same land use area that would result in higher risk. This is especially important when considering the complexity of multiple modeled air parameters and phases per location, potentially multiple facility emission sources, and multiple source-specific COPCs. This approach also provides more complete risk evaluation of areas surrounding the facility; information often required later in the permitting process and in risk communication to the surrounding public. Therefore, U.S. EPA OSW recommends that, at a minimum, a risk assessment initially evaluate current and reasonable potential future land use areas, defined during the exposure setting characterization, using the most representative recommended exposure scenario(s) at actual receptor grid nodes selected as follows:

***Step 1: Define Land Use Areas To Be Evaluated* -** Current and reasonable potential future land use areas, water bodies, and watersheds identified during exposure setting characterization for evaluation in the risk assessment, should be defined and mapped using UTM coordinates in a format (NAD27 or NAD83 UTM) consistent with that used to define locations of facility emission sources and the ISCST3 receptor grid nodes.

***Step 2: Identify Receptor Grid Node(s) Within Each Land Use Area To Be Evaluated* -** For each land use area to be evaluated, identify the receptor grid nodes within that area or on the boundary of that area (defined in Step 1) that represent the location of highest yearly average concentration for each ISCST3 modeled air parameter (e.g., air concentration, dry deposition, wet deposition) for each phase (e.g., vapor, particle, particle-bound); specific to each emission source (e.g., stacks, fugitives) and all emission sources at the facility combined. This results in the selection of one or more receptor grid nodes as one or more exposure scenario locations, within the land use area to be evaluated, that meet the following criteria:

- Highest modeled unitized vapor phase air concentration
- Highest modeled unitized vapor phase wet deposition rate
- Highest modeled unitized particle phase air concentration
- Highest modeled unitized particle phase wet deposition rate
- Highest modeled unitized particle phase dry deposition rate
- Highest modeled unitized particle-bound phase air concentration
- Highest modeled unitized particle-bound phase wet deposition rate
- Highest modeled unitized particle-bound phase dry deposition rate

With the exception of water bodies and watersheds (discussed in Step 4 below), only ISCST3 modeled air parameters corresponding to a single receptor grid node should be used per exposure scenario location as inputs into the media equations, without averaging or statistical manipulation. However, based generally on the number and location of facility emission sources, multiple exposure scenario locations may be selected for a specific land use area being evaluated. Application of these criteria for land use areas being evaluated in U.S. EPA Region 6 for actual sites, using actual modeled air parameters, indicates that only 1 to 3 receptor grid nodes are typically selected per land use area. This is because, in most cases, the location of highest air concentration and deposition rate occurs at the same receptor grid node. It should also be noted, that while these criteria minimize overlooking maximum risk within a land use area, they do not preclude the risk assessor from selecting additional exposure scenario locations within that same land use area based on site-specific risk considerations (see Step 3 below).

Step 3: Identify Receptor Grid Nodes For Acute Risk and Site-Specific Risk Considerations - In addition to the receptor grid nodes selected based on the criteria specified above, additional receptor grid nodes within the assessment area may need to be considered as exposure scenario locations for the evaluation of acute risk or site-specific risk considerations (e.g., special subpopulations). In land use areas to be evaluated for acute risk (could potentially include commercial and industrial land use areas), receptor grid nodes with the highest modeled hourly vapor phase air concentration and highest hourly particle phase air concentration (see Chapter 3), specific to each emission source and all emission sources at the facility combined, should be selected as the exposure scenario location(s). For site-specific risk considerations, the closest receptor grid node to the exposure point being evaluated should be considered for the exposure scenario location. However, in some cases, a more conservative approach may require selection of the closest receptor grid node or nodes with the highest modeled air parameter values.

Step 4: Identify Receptor Grid Nodes For Water Bodies and Watersheds - For recommended exposure scenarios that include evaluation of water bodies and their associated watersheds, the receptor grid nodes within their area extent or “effective” areas (defined and mapped in Step 1) should be considered. For water bodies, the risk assessor can select the receptor grid node with the highest modeled air parameter values or average the air parameter values for all receptor grid nodes within the area of the water body. For watersheds, the modeled air parameter values should be averaged for all receptor grid nodes within the area extent or effective area of the watershed (excluding the area of the water body). For water bodies and watersheds, air parameters to be considered as required by the estimating media concentration equations in Chapter 5 and Appendix B include yearly averages for each ISCST3 modeled air parameter (e.g., air concentration, dry deposition, wet deposition) for each phase (e.g., vapor, particle, particle-bound); specific to each emission source (e.g., stacks, fugitives) and all emission sources at the facility combined.

For the purpose of evaluating potential exposure routes other than ingestion of fish, the subsistence fisher and subsistence fisher child should be assumed to be located at selected exposure scenario locations where the adult resident scenario is evaluated. In addition, the subsistence fisher and subsistence fisher child exposure scenarios should be assumed to be exposed through ingestion of fish from the water body having the highest modeled combined deposition, and can or does support fish populations. In some cases, site specific conditions may require that the subsistence fisher and subsistence fisher child exposure scenarios be evaluated assuming exposure through ingestion of fish be calculated using COPC water concentrations from one water body, and exposure from ingestion of drinking water be calculated using COPC water concentrations from a different water body.

The recommended ISCST3 modeled receptor grid node array extends out about 10 km from facility emission sources (see Chapter 3). To address evaluation of land use areas, water bodies, or watersheds located beyond the coverage provided by the recommended receptor grid node array (greater than 10 km from the facility), the ISCST3 modeling can be conducted with an additional receptor grid node array specified to provide coverage of the area of concern, or the steps above can be executed using the closest receptor grid nodes from the recommended array. However, using the closest receptor grid nodes from the recommended receptor grid node array will in most cases provide an overly conservative estimate of risk since the magnitude of air parameter values at these receptor grid nodes would most likely be higher than at receptor grid nodes located further from the facility sources and actually within the area of concern.